Summation of light stimuli.—It is well known that stimuli, too brief to produce a visible reaction, if repeated at intervals not too long, lead to a response, just as continuous stimulation for a sufficient time does. WIESNER found that when intermittent light stimuli followed each other within double the period of their duration, reaction began as soon as though the plants had been continuously stimulated. Generalizing from this he concluded that summation of the stimuli occurred without loss during the intervals. TALBOT'S law, however, which holds with extreme exactness for the human eye, indicates that the effect of an intermittent light can only equal that of a constant one of lower intensity. Thus, if a light of intensity i acts for x seconds, at intervals of $3x$ seconds, its stimulating effect will be equal to that of a light of $i/4$ intensity. Obviously if this law be valid for heliotropic reactions of plants, reaction time, which alone WIESNER determined, cannot be a correct index of the effects of light as a stimulus. NATHANSOHN and PRINGSHEIM showed that this is so, and further undertook to make an extended comparison of the effects of constant and intermittent light stimuli.[8] Using such lights on opposite sides of seedlings of Brassica and Avena, they find that TALBOT'S law is valid for heliotropic phenomena within reasonable limits. Only when the frequency and duration of the illumination was greatly reduced, as to 1⅛ minutes duration with darkness 3⅜ minutes, did the point of physiological indifference depart from the optical one (determined by the photometer) in favor of the intermittent light. Thus they established that there was, for plants as for the eye, a so-called critical periodicity. When intermittent stimuli are too slow, the eye sees a flickering; the plant responds by pendulum-like swings instead of a steady curvature. They also found the law valid within wider limits with weaker illumination than with strong.

In an elaborate theoretical discussion they propose to account for the observed phenomena of summation thus: They assume, with HELMHOLTZ, that the primary excitation is photochemical, and that its effect is proportional to the product of the intensity by the time of illumination. This produces a certain excitation, which is steadily maintained in constant illumination, but falls in the dark interval of intermittent illumination. In both cases a counter-reaction is assumed to be released, which antagonizes the primary reaction, and must be overcome if the latter is realized visibly. With constant illumination the algebraic sum of the light excitation and the counter-reaction determines the maximum effect. In intermittent light the counter-reaction is effective in the dark intervals in reducing the effect of each excitation, the remainder being added to by the next impulse, which serves at the same time to heighten the counter-excitation, and so on. As we understand it, the case for constant illumination might be represented thus: $a-b=c$, a being the total direct excitation, b the total counter-excitation, and c the response, with intensity i. At the intensity $2i$, and alternate equal periods of light and darkness, the case is this: $(x-y)+[x-(y+k)]+n=c;$ where x is

9 NATHANSOHN, A. und PRINGSHEIM, E., Ueber die Summation intermittierende Lichtreise. Jahrb. Wiss. Bot. **45**:137–190. 1907.

the direct excitation of each stimulus, y the counter-excitation set up thereby, k the increment of y, n any number of additional terms, and c the response. No good reason appears for assuming a counter-reaction. Partial or complete recovery from the primary excitation in the intervals of stimulation is a simpler assumption and would seem equally to account for the facts. Further details must be sought in the paper itself.—C. R. B.

Edaphic steppes in Sweden.—The "alfvar" is a name given in Sweden to some remarkable formations that occur chiefly on the island of Öland, and to a lesser degree on the island of Götland, and in the mainland province of Vestergötland. The name "alfvar" is applied to extensive treeless plains, whose underlying rock is a Silurian limestone. While there are several plant formations, the alfvar presents general ecological unity, and it has an extremely xerophytic stamp. It is somewhat similar to the "garigue" of southern Europe, and to certain rock formations of Servia. The physiognomy is that of a steppe, and yet there is anything but a steppe climate in Sweden. There is no question that the alfvar is determined by edaphic causes in the main (such as the dryness and temperature changes of the rocks, which are everywhere at or near the surface, and the poverty of the scanty soil), reinforced by strong insolation and constant winds. The alfvar is very distinct in every way from the heath. Such a region is relatively rich in species, of which more than half are glacial or subglacial, and about a third are representatives of the oak flora. Six per cent. belong to the climatic steppe, and only 2 per cent. to the beech forest flora. This flora is doubtless a relict of a much more widespread flora in the period succeeding glaciation. There are two general aspects, the dominant aspect of the steppe, and the lesser aspect of the meadow. The herbaceous plants commonly dominate, although shrubs are frequently conspicuous. The leading character plants of the steppe are *Mollia tortuosa*, *Helianthemum oelandicum*, and *Cynanchum vincetoxicum*. The chief shrubs are *Juniperus communis* and *Potentilla fruticosa*. In less xerophytic places, *Festuca ovina* assumes a prominent place. There are often vast areas of Cynanchum almost alone, giving almost an exact picture of certain climatic steppes. Perhaps the most interesting part of the paper is the discussion of nanism. The author distinguishes facultative dwarfs, due to environmental causes, and constitutional dwarfs. Constitutional dwarfs (the group to which the term nanism more properly applies) differ from facultative dwarfs not only in breeding true, regardless of conditions, but also in a much greater qualitative reduction. Constitutional dwarfs show reduction in all organs, not chiefly in aerial vegetative organs; roots and rhizomes are reduced, while they are rarely reduced and often actually increased in facultative dwarfs. Constitutional dwarfs also show reduced floral organs, their internodes are fewer as well as shorter, and their leaves are reduced in number as well as in size. Most of the dwarfs are annuals, although some show a certain lability as to their duration. Species commonly perennial or biennial, for example, may become annual in very dry situations. The usual "protective" structures of xerophytic vegetation occur